David Kirby

Course ID: ECE 440 Introduction to Computer Networks-Spring
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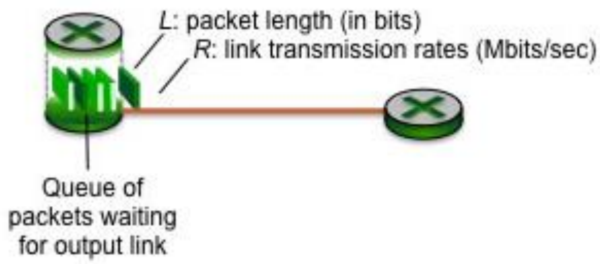
326B/ Office Hours: Tuesdays and Thursdays 2:00pm-3:00pm
Lectures: Tuesdays and Thursdays 3:30pm-4:45pm, Room: EECE 118
Department of Electrical and Computer Engineering / University of New Mexico

Midterm Exam

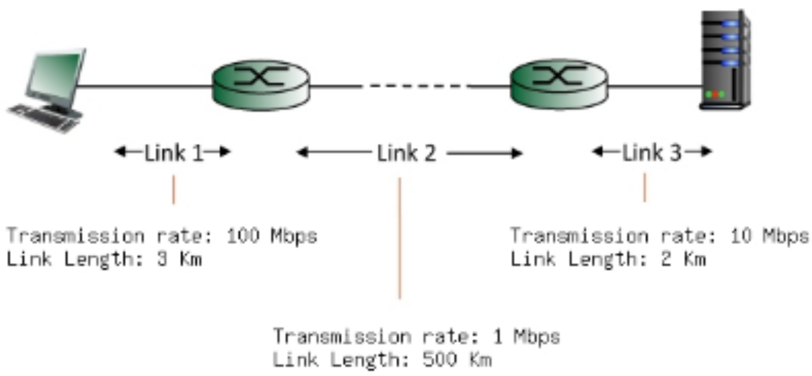
1. (20%) Consider the figure below, in which a single router is transmitting packets, each of length L bits, over a single link with transmission rate R Mbps to another router at the other end of the link.



Suppose that the packet length is L= 8000 bits, and that the link transmission rate along the link to router on the right is R = 1000 Mbps.

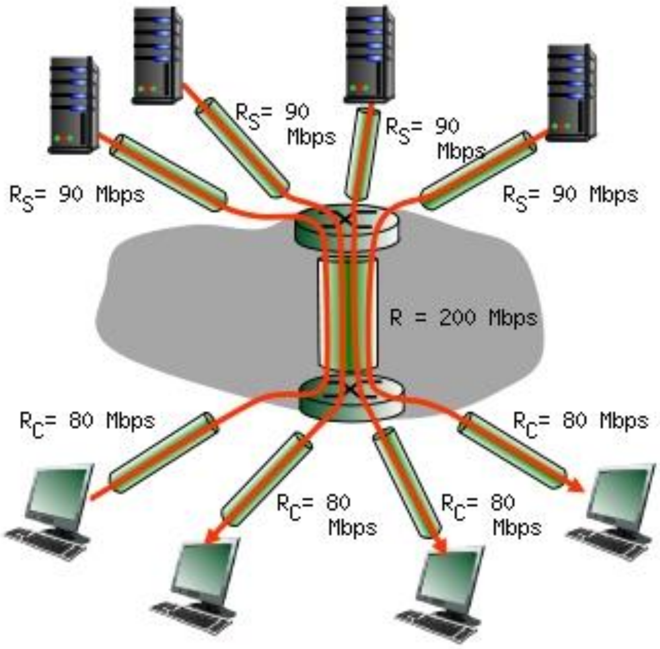
(a) What is the transmission delay (the time needed to transmit all of a packet's bits into the link)? **(10%)**
(b) What is the maximum number of packets per second that can be transmitted by the link? **(10%)**

2. (20%) Consider the figure below, with three links, each with the specified transmission rate and link length.



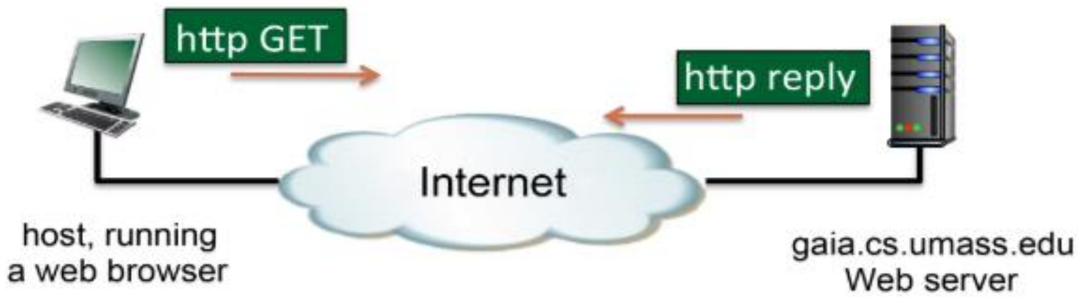
Find the end-to-end delay (including the transmission delays and propagation delays on each of the three links, but ignoring queueing delays and processing delays) from when the left host begins transmitting the first bit of a packet to the time when the last bit of that packet is received at the server at the right. The speed of light propagation delay on each link is 3x10**8 m/sec. Note that the transmission rates are in Mbps and the link distances are in Km. Assume a packet length of 12000 bits. Give your answer in milliseconds.

3. (20%) Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 200 Mbps. The four links from the servers to the shared link have a transmission capacity of RS = 90 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of RC = 80 Mbps per second.



a) What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fair-shared (i.e., divides its transmission rate equally among the four pairs)? **(5%)**
b) Which link is the bottleneck link for each session? **(8%)**
c) Assuming that the senders are sending at the maximum rate possible, what are the link utilizations for the sender links (RS), client links (RC), and the middle link (R)? **(7%)**

4. (20%) Consider the figure below, where the server is sending a HTTP RESPONSE message back the client.



Suppose the server-to-client HTTP RESPONSE message is the following:

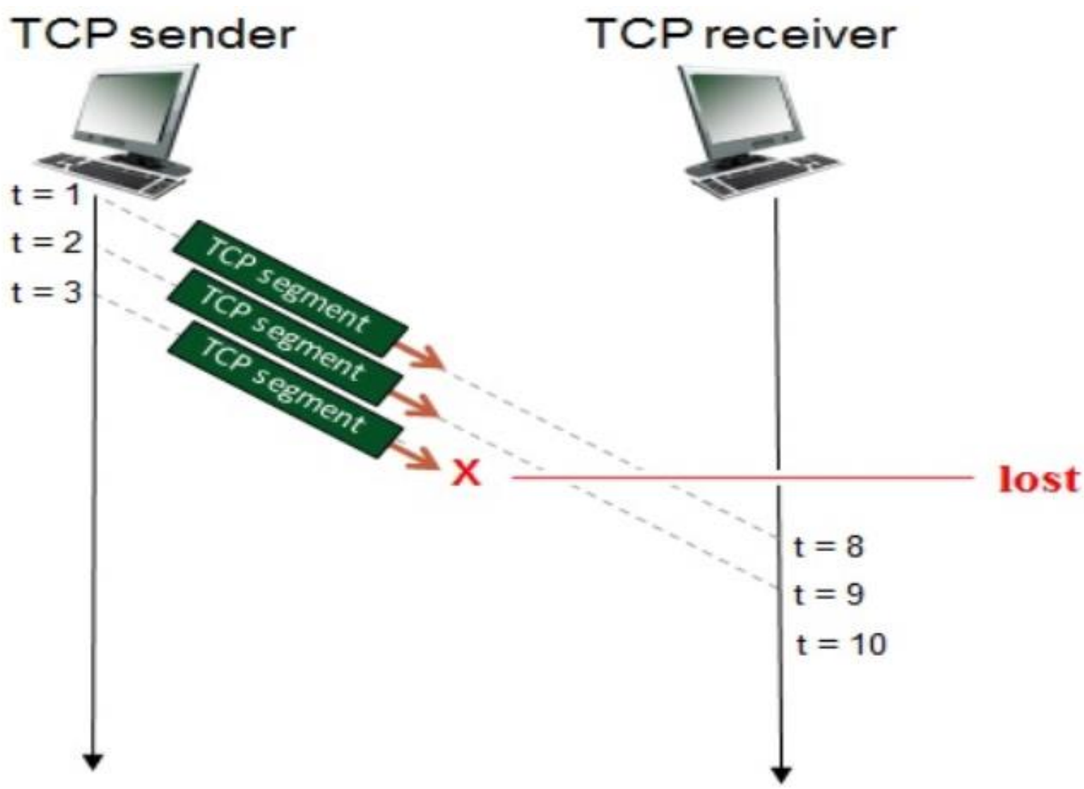
```
HTTP/1.0 404 Not Found
Date: Tue, 07 Apr 2020 15:15:57 +0000
Server: Apache/2.2.3 (CentOS)
Content-Length: 957
Connection: Close
Content-type: text/html
```

Answer the following questions:

A. Is the response message using HTTP 1.0 or HTTP 1.1? Explain. **(4%)**
B. Was the server able to send the document successfully? Explain **(4%)**

C. At what date and time was this response sent? **(4%)**
D. How many bytes are there in the document being returned by the server? **(4%)**
E. What is the name of the server and its version? **(4%)**

5. (20%) Consider the figure below in which TCP a sender and receiver communicate over a connection in which the sender-to-receiver segments may be lost. The TCP sender sends initial window of three segments at t=1,2,3, respectively. Suppose the initial value of the sender-to-receiver sequence number is 123 and the first three segments each contain 554 bytes. The delay between the sender and the receiver is 7 time units, and so the first segment arrives at the receiver at t=8. As shown in the figure, one of the three segment(s) is lost between the sender and the receiver.

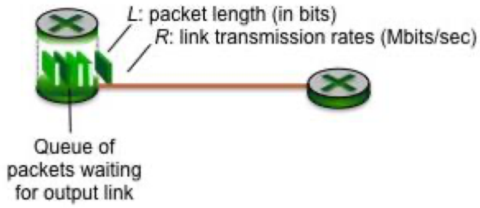


Answer the following questions:

1. Give the sequence numbers associated with each of the three segments sent by the sender **(10%)**
2. List the sequence of acknowledgements transmitted by the TCP receiver in response to the receipt of the segments actually received. In particular, give the value in the acknowledgement field of each receiver-to-sender acknowledgement, and give a brief explanation as to why that particular acknowledgement number value is being used **(10%)**

Good Luck!

1. **(20%)** Consider the figure below, in which a single router is transmitting packets, each of length L bits, over a single link with transmission rate R Mbps to another router at the other end of the link.



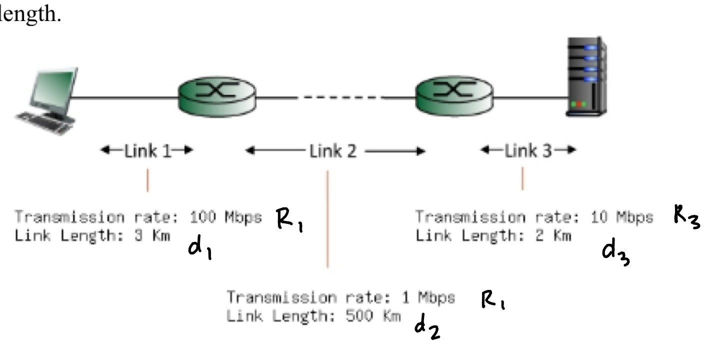
Suppose that the packet length is L= 8000 bits, and that the link transmission rate along the link to router on the right is R = 1000 Mbps.

(a) What is the transmission delay (the time needed to transmit all of a packet's bits into the link)? **(10%)**
(b) What is the maximum number of packets per second that can be transmitted by the link? **(10%)**

(a) $d_{trans} = \frac{L}{R} = \frac{8000 \text{ bits}}{1000 \times 10^6 \frac{\text{bits}}{s}} = \boxed{8.0\ \mu s}$

(b) $8\mu s$ per packet $\rightarrow \frac{1s}{8\mu s} = \boxed{125{,}000 \text{ packets per sec}}$

2. **(20%)** Consider the figure below, with three links, each with the specified transmission rate and link length.



Find the end-to-end delay (including the transmission delays and propagation delays on each of the three links, but ignoring queueing delays and processing delays) from when the left host begins transmitting the first bit of a packet to the time when the last bit of that packet is received at the server at the right. The speed of light propagation delay on each link is 3x10**8 m/sec. Note that the transmission rates are in Mbps and the link distances are in Km. Assume a packet length of 12000 bits. Give your answer in milliseconds.

$s = 3\times10^8 \text{ m/s}$

$L = 12\,000 \text{ bits}$

Link 1

$d_{end\text{-}to\text{-}end} = d_{prop} + d_{trans} = \frac{m}{s} + \frac{L}{R}$

$d_{e2e\,1} = \left(\frac{3000 m}{3\times10^8 \text{ m/s}}\right) + \left(\frac{12000 \text{ bits}}{100\times10^6 \text{ bits/s}}\right) = 0.130 \text{ ms}$

Link2

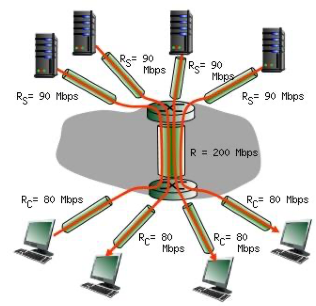
$d_{e2e\,2} = \left(\frac{500000 m}{3\times10^8 \text{ m/s}}\right) + \left(\frac{12000 \text{ bits}}{1\times10^6 \text{ bits/s}}\right) = 13.667 \text{ ms}$

Link3

$$d_{e2e_3} = \left(\frac{2000m}{3\times10^8 \, m/s}\right) + \left(\frac{12000 \text{ bits}}{10\times10^6 \text{ bits}/s}\right) = 1.2067\,ms$$

$$d_{total} = d_{e2e_1} + d_{e2e_2} + d_{e2e_3} = 15.003\,ms$$

3. **(20%)** Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 200 Mbps. The four links from the servers to the shared link have a transmission capacity of RS = 90 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of RC = 80 Mbps per second.



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b) Which link is the bottleneck link for each session? **(8%)**
c) Assuming that the senders are sending at the maximum rate possible, what are the link utilizations for the sender links (RS), client links (RC), and the middle link (R)? **(7%)**

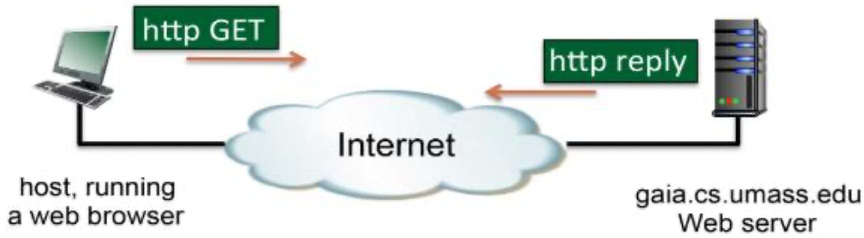
(a) middle link fair-shared $\rightarrow \frac{200\,Mbps}{4} = 50\,Mbps$

so even though client has 80 Mbps, the maximum end-to-end throughput is 50 Mbps.

(b) the common middle hop is the bottleneck

(c) Max rate for RS, RC, and middle (R) is all 50 Mbps

4. (20%) Consider the figure below, where the server is sending a HTTP RESPONSE message back the client.



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Answer the following questions:

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B. Was the server able to send the document successfully? Explain **(4%)**
C. At what date and time was this response sent? **(4%)**
D. How many bytes are there in the document being returned by the server? **(4%)**
E. What is the name of the server and its version? **(4%)**

(a) HTTP 1.0 as boxed above

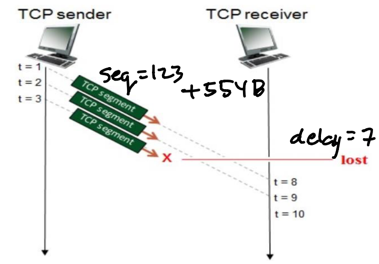
(b) no, document not found

(c) Tue, 07 Apr 2020 15:15:57 + 0000 (GMT)

(d) 957 bytes

(e) Apache/2.2.3

5. (20%) Consider the figure below in which TCP a sender and receiver communicate over a connection in which the sender-to-receiver segments may be lost. The TCP sender sends initial window of three segments at t=1,2,3, respectively. Suppose the initial value of the sender-to-receiver sequence number is 123 and the first three segments each contain 554 bytes. The delay between the sender and the receiver is 7 time units, and so the first segment arrives at the receiver at t=8. As shown in the figure, one of the three segment(s) is lost between the sender and the receiver.



1. Give the sequence numbers associated with each of the three segments sent by the sender **(10%)**
2. List the sequence of acknowledgements transmitted by the TCP receiver in response to the receipt of the segments actually received. In particular, give the value in the acknowledgement field of each receiver-to-sender acknowledgement, and give a brief explanation as to why that particular acknowledgement number value is being used **(10%)**

1)

seg #	time sent	seq #	time rec.	ACK #
1	t=1	123	t=8	123+554 = 667
2	t=2	667	t=9	667+554 = 1231
3	t=3	1231	—	—

2) please see chart above for seq of ACK transmitted. This value comes from the original sequence # plus the the size of each packet.